PALOMAR ENGINEERS®

RFI Solutions from KHz to GHz

Quick & Easy RFI Solutions

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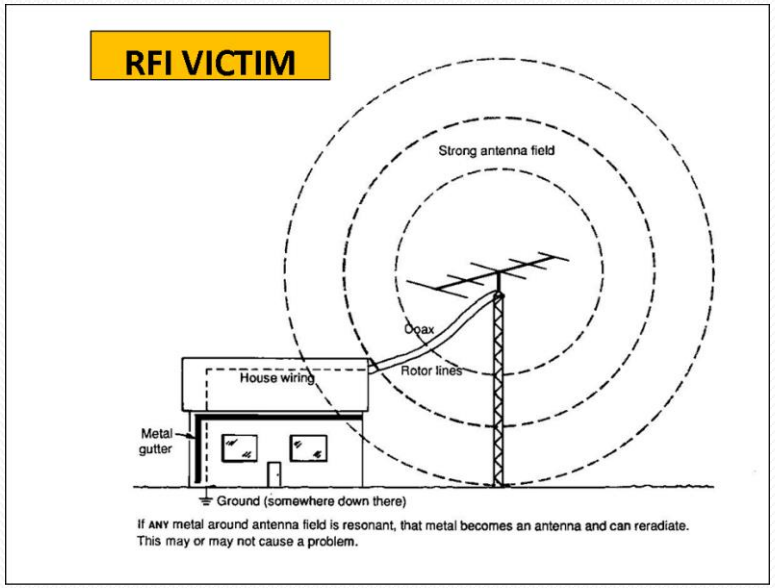
Palomar-Engineers.com

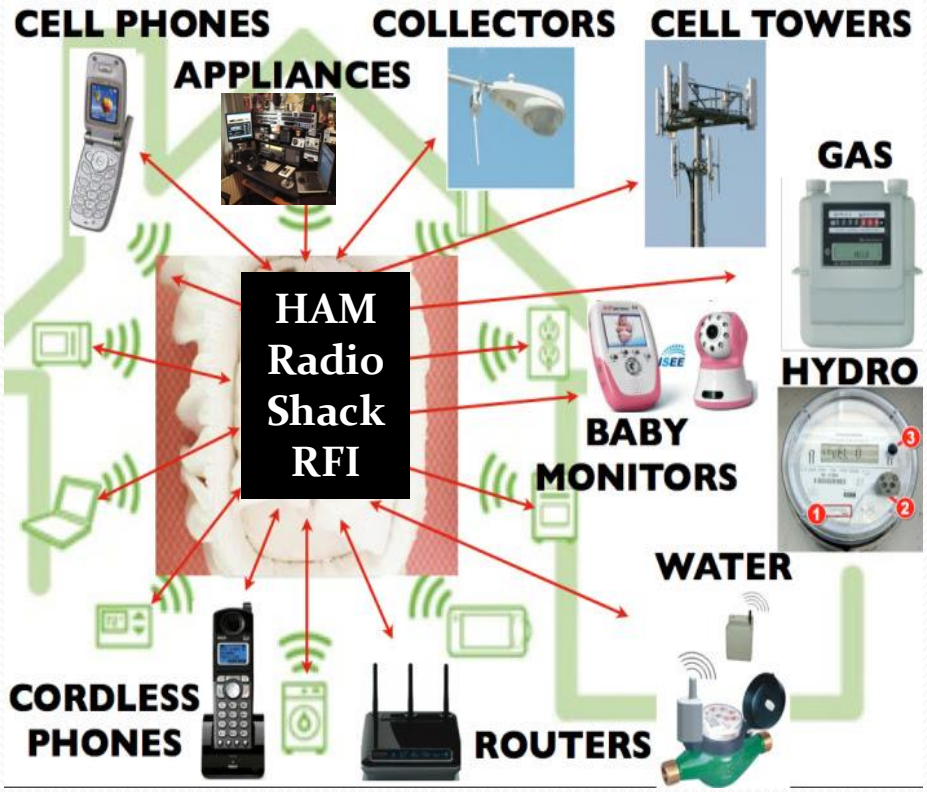
Amateur Radio Club of El Cajon July 2018
This presentation available on website

Are you the **SOURCE** of RFI?



IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

Are you a **VICTIM** of local RFI?



RFI Sources

- Ham Antenna
- Radiating Coax
- Electronic Devices
- Solar Systems
- Grow Lights
- HVAC motor
- Plasma TV
- DSL/Routers
- Switching power Supplies
- Washer/Dryer or other appliances

QRN - High Noise Floor – Weak Signals – NO DX – No fun!

RFI Workshop Objectives

- Understanding RFI - definition, symptoms, transmission paths, simple cures
- Ferrite Fundamentals - how to select, configure, and buy the right ferrite for your RFI issue
- How to suppress your transmitter RFI using ferrites
- How to reduce your receiver noise floor using ferrites
- Understand CONCEPTS with little or NO MATH required

Thinking cap time……

RFI 101

What is RFI?

How is it transferred?

Typical Symptoms

RFI “Antennas”

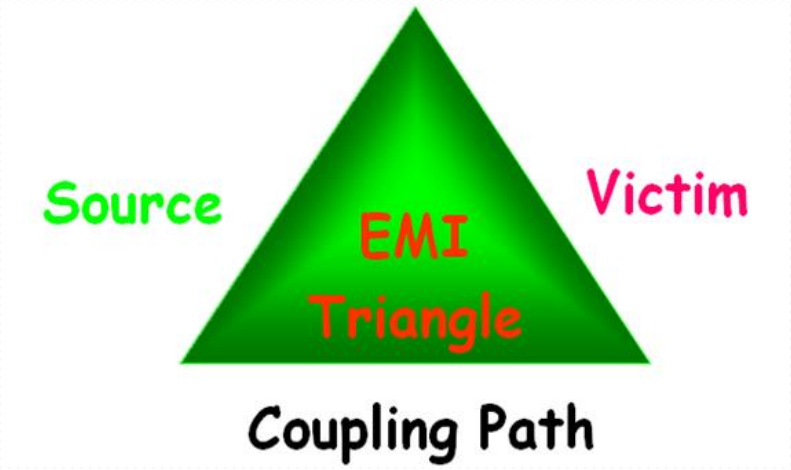
RFI Cures

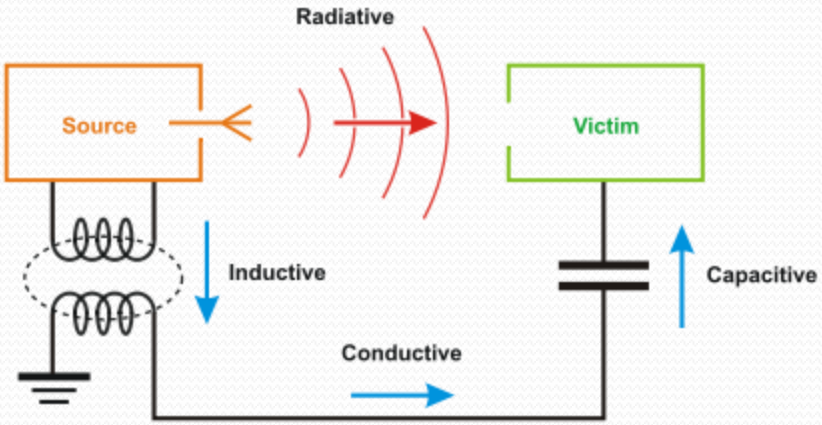
What is RFI?

- ***A radio frequency (>100 KHz) disturbance that causes an electrical circuit to function improperly***
  Common **Sources**
  - Sunspots, Cosmic noise, Lightning, atmospheric static, AC power lines (**no fix**)
  - "Transmitters" -Ham, CB, AM/FM, electronic devices, speed controllers, inverters, switching power supplies, computer electronics, Cable/DSL/Ethernet (**can use filters to fix**)
- Common **Victims**
  - Any electronic device that malfunctions by acting as an unintended "receiver" of RFI

How do you get RFI?

How RFI is Transferred





Source (antenna) and **Victim** (antenna) coupled via **Path** (all must be present to have RFI)

Multiple paths are very common:

1. Radiative - air
2. Conductive – wire(s)
3. Inductive - wire
4. Capacitive - wire

How to find the source & path

Typical RFI in your shack/home

- **TX Symptoms** – caused by your transmitter or antenna
  - Hot microphone – RF lip burns, distorted audio
  - Antennas don't tune correctly, high SWR, radiating coax
  - Your voice/transmission causes interference with consumer electronic devices acting as ham radio frequency "receivers" (e.g. computers, TV/audio system, security system, garage door opener, telephone, sprinkler systems, lights, etc.)
  - Wife Alarm goes off
- **RX Symptoms** – caused by sources outside your radio
  - High receive noise level not due to atmospheric conditions
  - Birdies, chirps, buzzes, clicks, broadband noise on receiver
  - Distorted receiver audio

"Antennas" & paths

Typical RFI receiving “antennas"

- **AM broadcast, 160-80-60-40-30 meter RFI** – long “antennas” - AC power lines, telephone/DSL lines, satellite/cable coax, long Ethernet cables, antenna feed line coax shield, antenna control/rotor cables, 2nd story ground wires (avoid ¼ wavelength ground wires)
- **FM broadcast, 20-2 meter transmitter RFI**,– short “antennas” - speaker wires, device interconnect cables, mic cables, short Ethernet cables

- “Antennas” pick up radiated or conducted RFI and a common mode current is induced on ALL unshielded antenna conductors from an RFI SOURCE

So how do we reduce this current?

Curing RFI Issues

I (RFI Current) = E (TX voltage)/R (Choking resistance)

- Shut down the SOURCE (Set E to zero)
- Choke the PATH (minimize E, increase R)
- Protect the VICTIM(Set R very high)

Objective: Minimize RFI current, I

Trivia Q: Why is current abbreviated with I and not C?

Using ferrites to cure RFI

Ferrite Fundamentals

How to Select,

Buy,

Configure,

and Apply

Ferrite Topologies (Shapes)

Slip On Bead

Snap On Bead

Toroid or Ring

Fuzzy Ferret – not!

CHARACTERISTICS

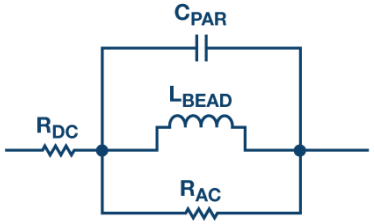
- Cheap, easy to install, suppress RFI from 100 KHz - 2 GHz
- Work on all conductive paths (antenna feed line, AC/DC, I/O cables)
- Lots of options in size, shape to suppress most RFI path currents
- Are effective if you understand how ferrites work, how to choose the correct ferrite and where to install the ferrite for a particular RFI problem

Ferrite characteristics can be used to reduce RFI common mode current

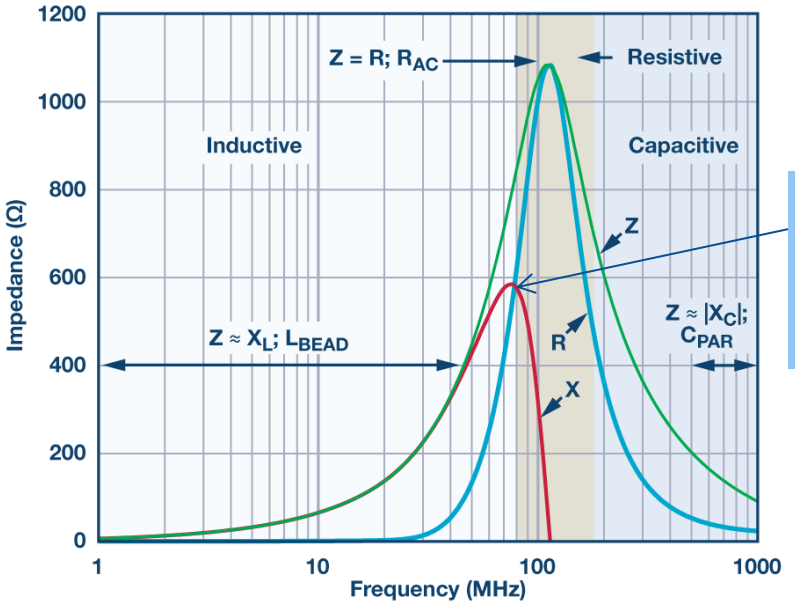
How do Ferrites Work?

Simple Equivalent Circuit – parallel tuned circuit with a high impedance resonance

Acts like a frequency dependent resistor to RFI



(a)



Resistive region starts here – 80 MHz to 300 MHz

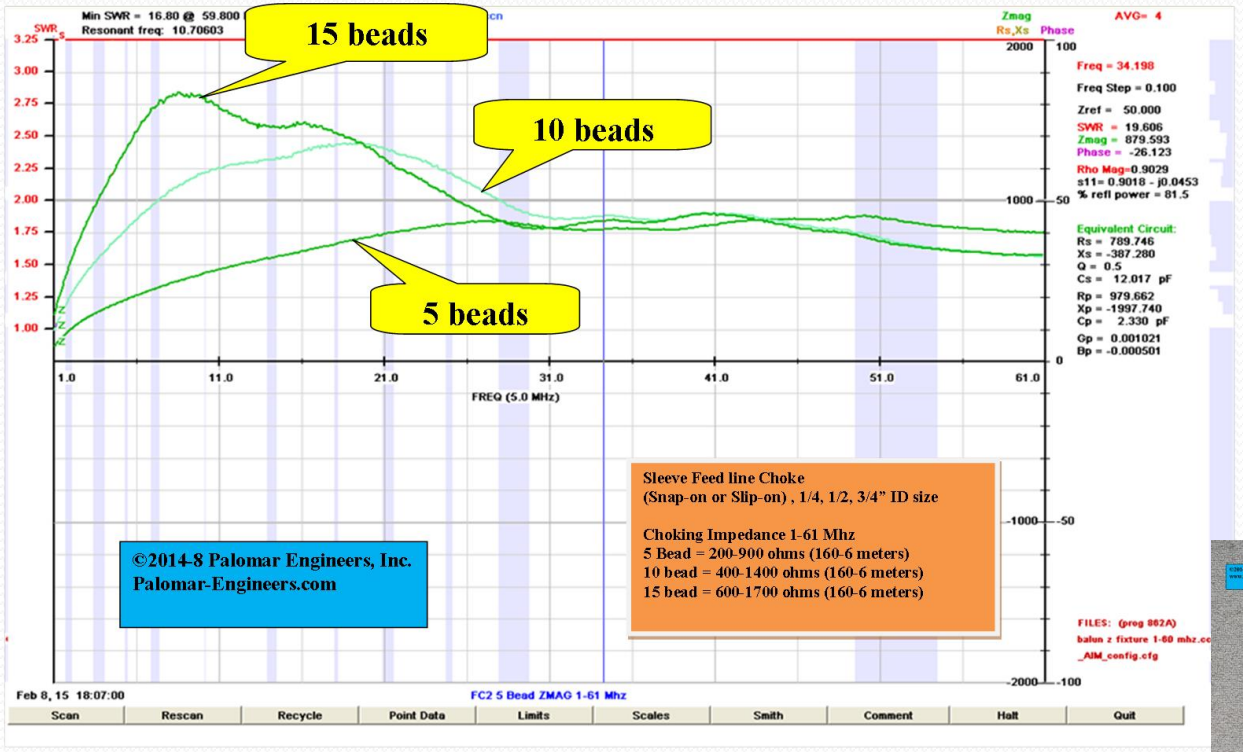
(b)

Ferrite beads are categorized by three response regions: inductive, resistive, and capacitive. ***To reduce high frequency interference (noise), <u>the bead must be used in the resistive region where it acts like a resistor,</u> which impedes the common mode current (noise) and dissipates it as heat***.

Objective: reduce common mode current by increasing choking resistance

Ferrite resistors add in series

Impedance



Frequency →

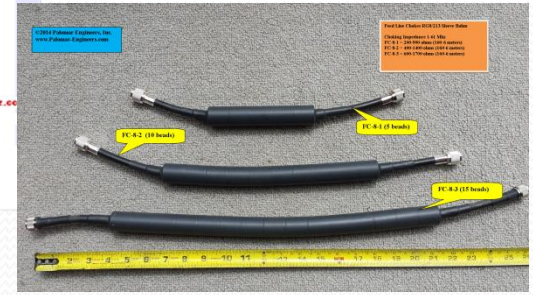
More beads =

higher choking R
(up to 30 MHz)

At 7 MHz:
5 beads = 400Ω

10 bead = 1000Ω

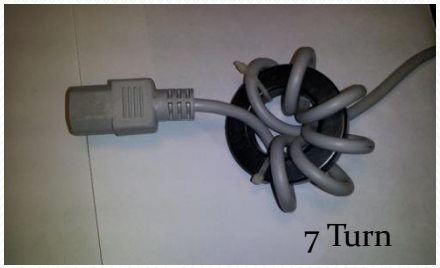
15 beads = 1600Ω



Impedance (Z) = Resistance +/- Reactance

Ferrite resistors increase as (turns)^2

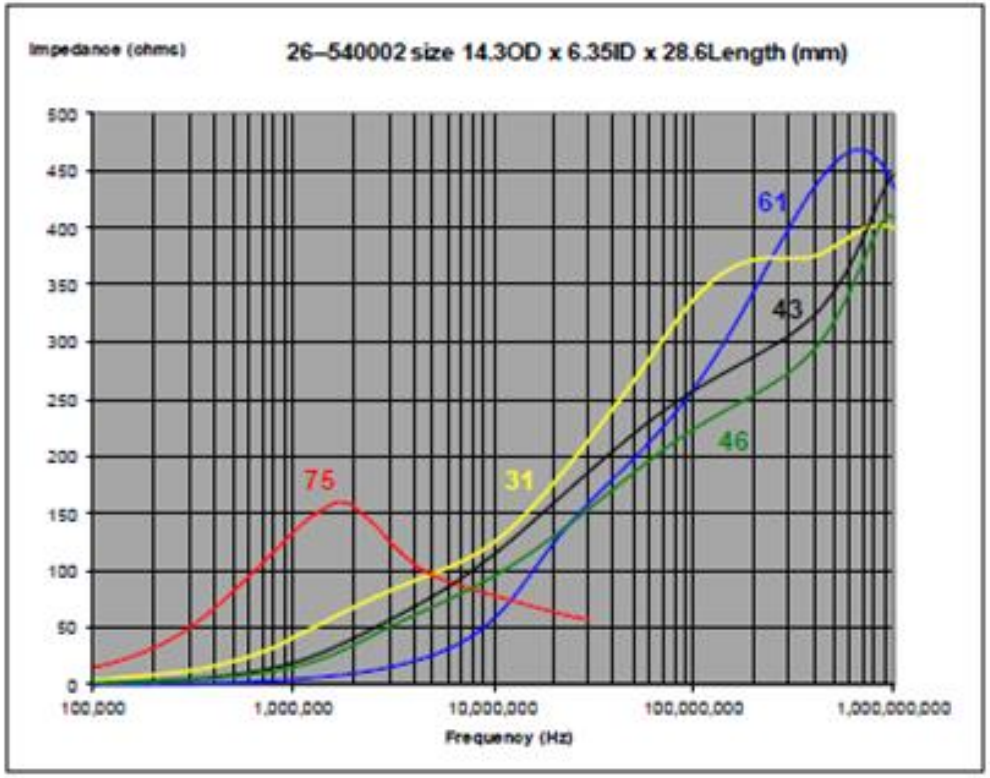
- If 1 turn = R, 2 turns = 4 x R, 3 turns = 9 x R
- More R = less RFI wire current = less RFI radiated from wire or induced into wire. (I=E/R)
- ***General rule: choking R > 10X line impedance***
- (e.g. > 500 Ω for 50 Ω cable but 5000 Ω is 10x better)



7 MHz: 100Ω 900Ω 2500Ω

Question: How do we choose the correct ferrite for the RFI frequency?

Ferrite Mix determines frequency range of effectiveness



Mix = chemical formula of the iron oxide with manganese-zinc (31, 75) or nickel-zinc (43, 61)

<u>Select mix for max R at RFI fundamental frequency NOT frequency of receiver.</u>

Example:
for .1-10 MHz use mix 75/77
for 1-300 MHz use mix 31
for 20-250 MHz use mix 43
for 200-2000 MHz use mix 61

Most popular ham frequency mixes are 31, 43, 61, 75, 77.

Wrong or unknown mix will probably not work so…… Know how to buy

How NOT to buy ferrites!

=

DON'T

BUY!!!

- **NO** Mix Designation
- **NO** Resistance/Impedance Range
- **NO** Frequency Range = No No No!

Buying unknown ferrites is like buying a box of rocks - a waste of time and money!

Another Alternative?

How to buy Ferrites the **right** way!

PALOMAR ENGINEERS®

RFI Solutions from KHz to GHz

Ferrite Split Beads
10 Pack -1/2" ID
RFI Range: 1-300 MHz
Mix 31

Single turn, each bead provides:
71Ω/5 MHz, 100Ω/10 MHz
156Ω/25 MHz, 260Ω/100 MHz,
260Ω/250 MHz

For: AC/DC Power, Coax, Ethernet, Audio/Video Cables

Multiple turns for best results

Part # FSB31-1/2-10

=

BUY With CONFIDENCE!!

Product Labeling (Mix, Frequency, Impedance) + Known Vendor = Winner!

So let's recap RFI 101

Ferrite Use Recap

- Determine RFI interfering frequency & suspected Path
- Choose proper mix (31, 43, 61, 75/77) to suppress RFI <u>fundamental</u> frequency
- Choose Topology(slip, snap, ring) to fit the Path "Antenna"
- Install ferrites – retest for RFI suppression
- Consider additional ferrites or Paths if RFI persists

<u>Most popular Mix for HF is MIX 31 (1-300 MHz)</u>

<u>(Mix 75/77 for .1-10 MHz, Mix 61 for 200-2000 MHz)</u>

How and where do you put the ferrite band aid for transmitter RFI?

Transmitter RFI Solutions

Practical Tips to minimize transmitter source RFI

Tip #1 - Install Transceiver, Linear Amp RFI Filters

Goal: Minimize SOURCE RFI from radio and amplifier “antennas”

RFI Chokes for Transmitters/Amps

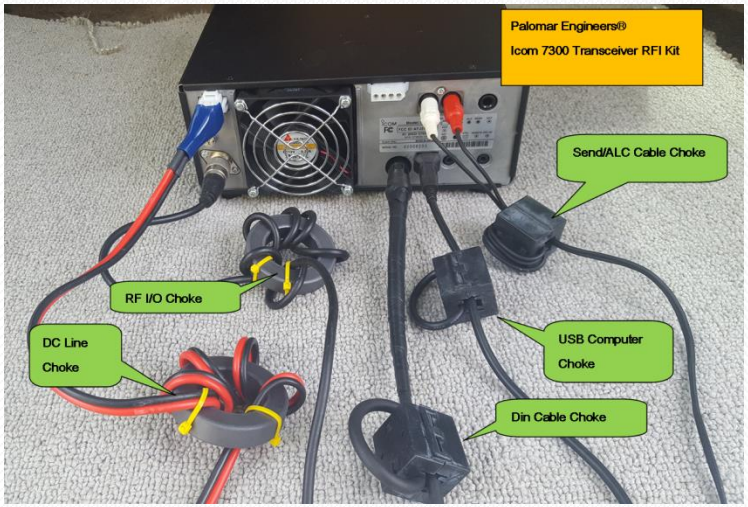
- Transmitter – Amplifier - Antenna RFI suppression
  - Choke all cables into/out of radios, amplifier, antenna tuners
  - Includes
    - ALL Coax RF feed lines or common line of coax switch
    - Rotor/Antenna Control lines
    - AC/DC power Lines including wall warts!
    - Computer – all radio interconnects, AC power
    - Examples on next slides
  - Recommendation: Filter ALL power cables to equipment and buy Palomar transceiver, amplifier and computer RFI kits with mix, sizes, instructions already pre-determined.

Transceiver/Amp Examples

Transceiver/Amp RFI Kits

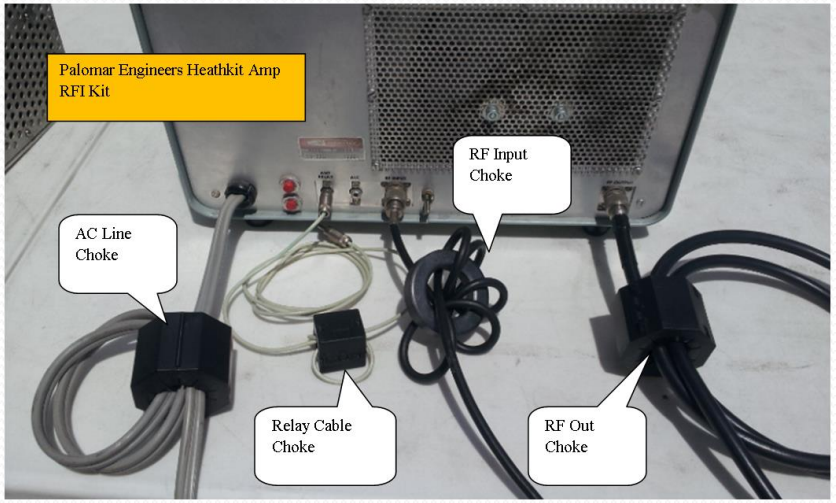
Palomar RFI kits for all brands of transceivers and amplifiers

Transceiver RFI Kit



ICOM 7300

Linear Amplifier RFI Kit



HEATHKIT SB220

Clean up the RFI **SOURCE** first – <u>your radio and amp</u>

Tip #2. Stop Transmit RFI current on coax braid

ALL coax fed antennas need a feed line choke at the antenna feed point!!!!!

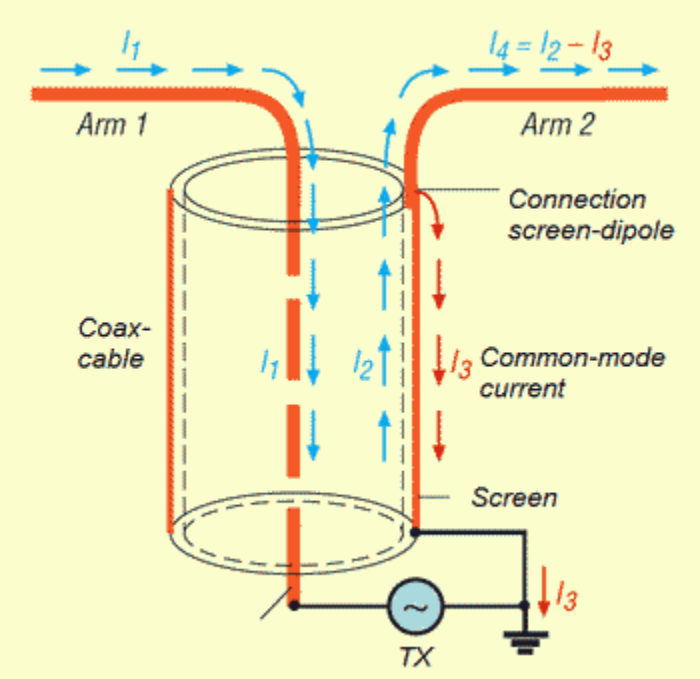
OR

Your dipole will become a tripole

Your unipole (vertical) will become a dipole

Is your Dipole a Tripole?

- Coax <u>outside</u> of braid acts as extension of <u>transmitting</u> antenna and extra <u>receive</u> antenna



<u>Coax cable has 3 conductors</u>!

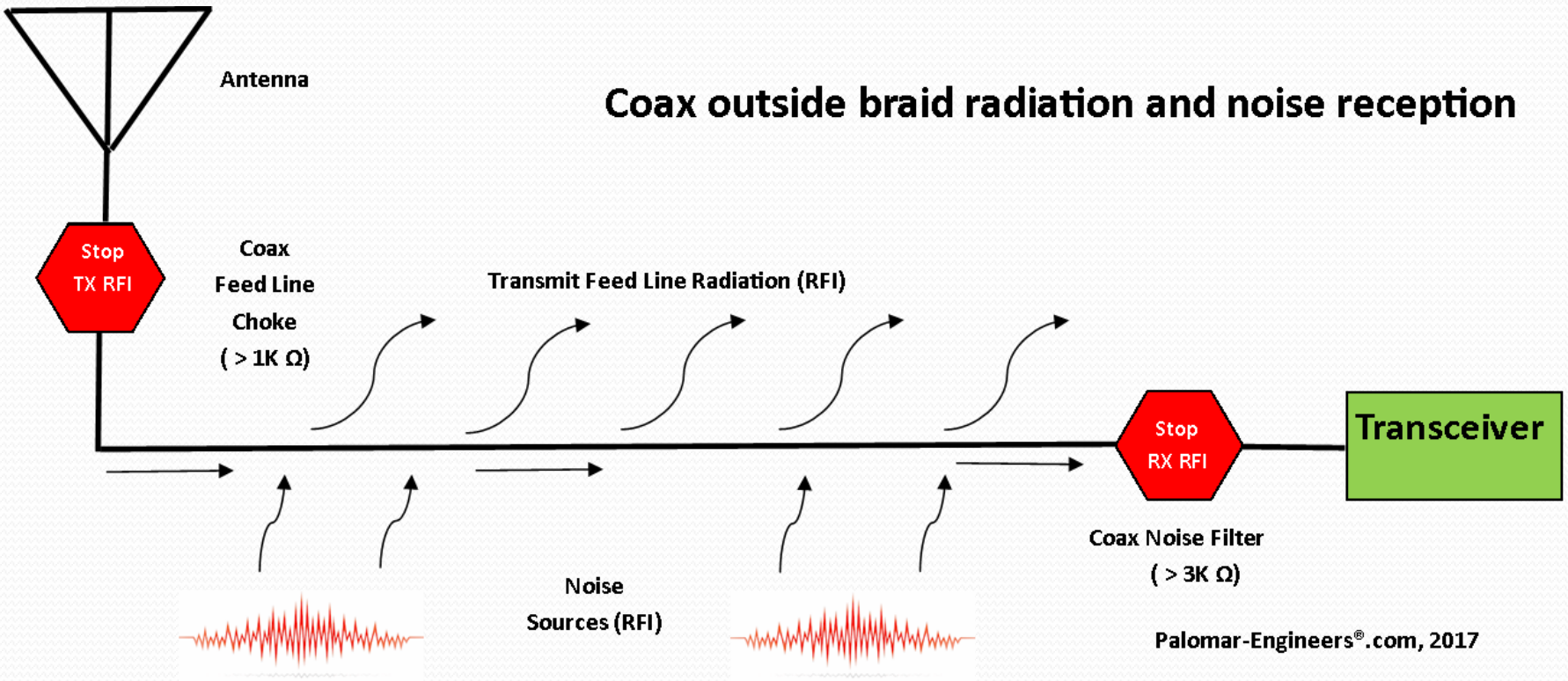
Coax <u>braid</u> is actually 2 conductors :
1 on the inside (normal RF signal), and
1 on the outside (common mode current)
that turns a dipole into tripole on transmit or a second antenna on receive!

<u>Goal is to reduce common mode current with a feed line choke to keep all transmit RF on antenna and use a coax noise filter to minimize noise into receiver.</u>

FYI: 1% common mode braid current = 2.75 watt radiation at 1500 watts input, or 1.6 watts at 500 watts input or .7 watts at 100 watts input

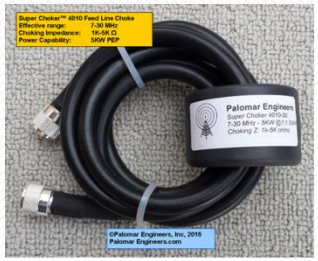
Typical Coax Antenna

Typical Coax Fed Antenna System



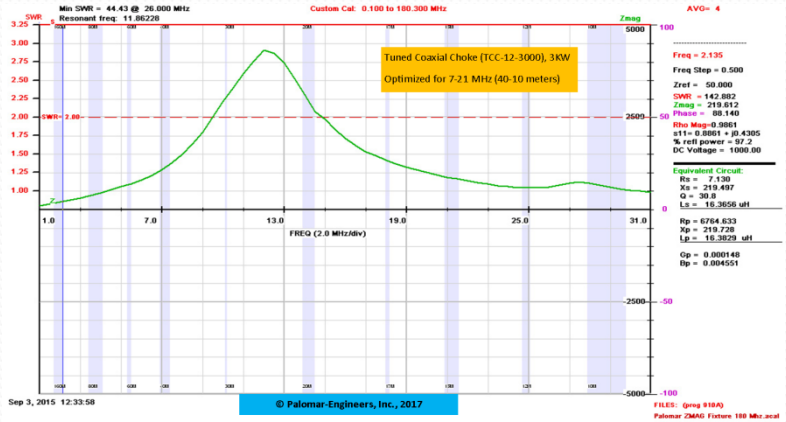
Technical requirements for feed line choke selection

Choosing a Feed Line Choke

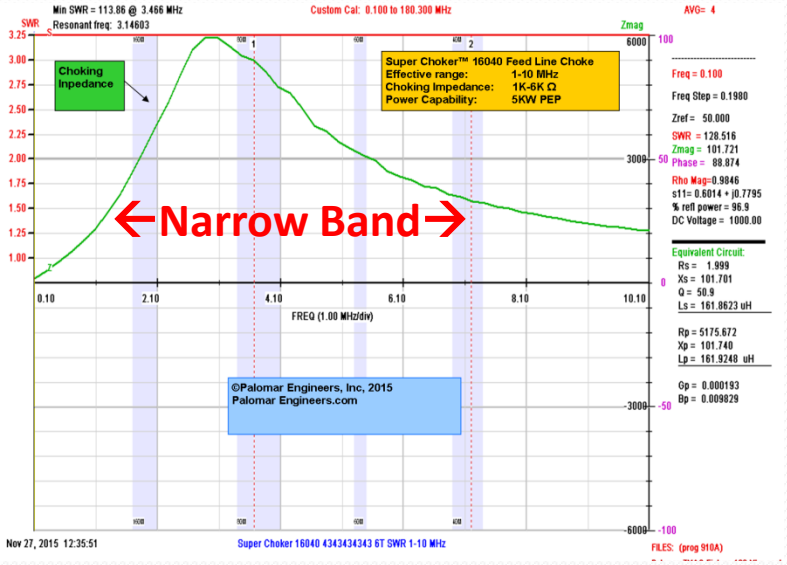


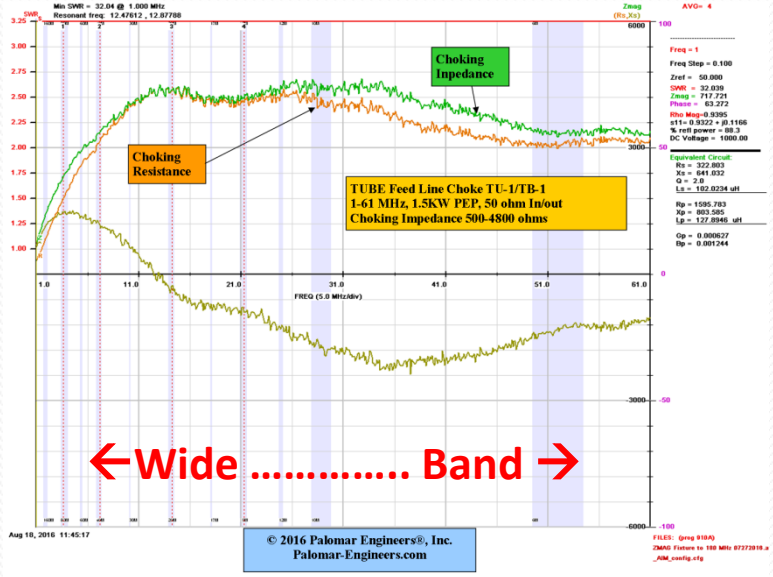
Criteria to Consider

- Effective Frequency Range
- Adequate Choking Impedance > 500Ω
- Sufficient Power Rating
- Physical Size/weight
- Balun or unun output

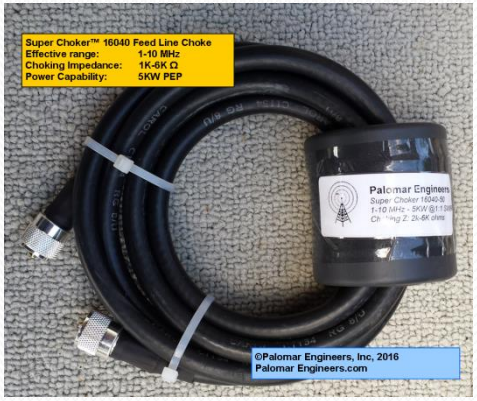


Choose choking resistance > 500Ω over frequency range used





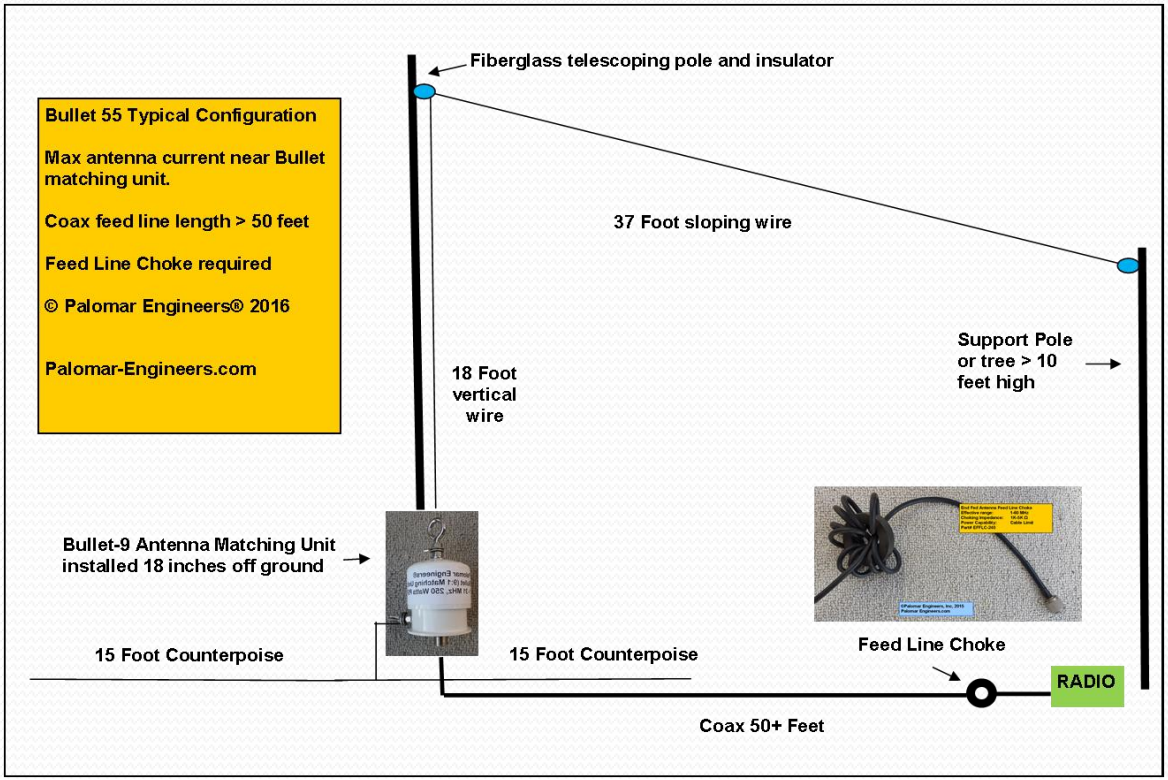
Super Choker
1-10 MHz >2K
5KW PEP
1K-6K Z
3 pounds
Verticals
AM/RTTY
Contesting



Line isolator
1-160 MHz >2K, 1.5KW PEP, 1K-6K ZΩ, 1 pound. All coax lines, Optional ground, static bleeder

DO NOT BUY CHOKES with NO SPECS!

Simple DIY Feed Line Chokes



Use 1.4" ID Ring with multiple turns

Let's Recap

Ham's Transmitter RFI Strategy

1. **Eliminate/reduce RFI SOURCE**
   (transmitter, amplifier RFI kits, move antenna location)

- or

2. **Choke the PATH**
   - (coax feedline chokes, AC/DC power line chokes)

Now What About Receiver RFI?

Receiver RFI Solutions

Our Goal: Lower Noise Floor = Higher SNR = More DX!

Tip #3. Install Coax Noise Filters

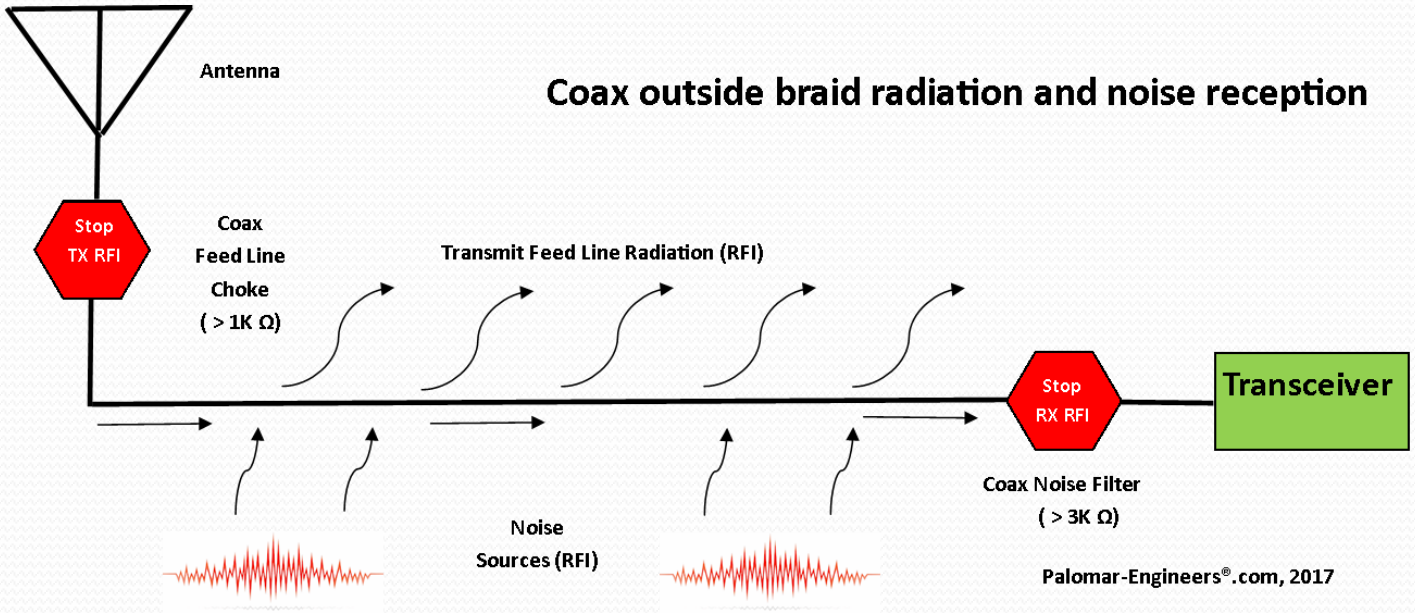
Less common mode noise current (RFI) = More DX!

How to select and install filters for maximum effect

Receive RFI Problem

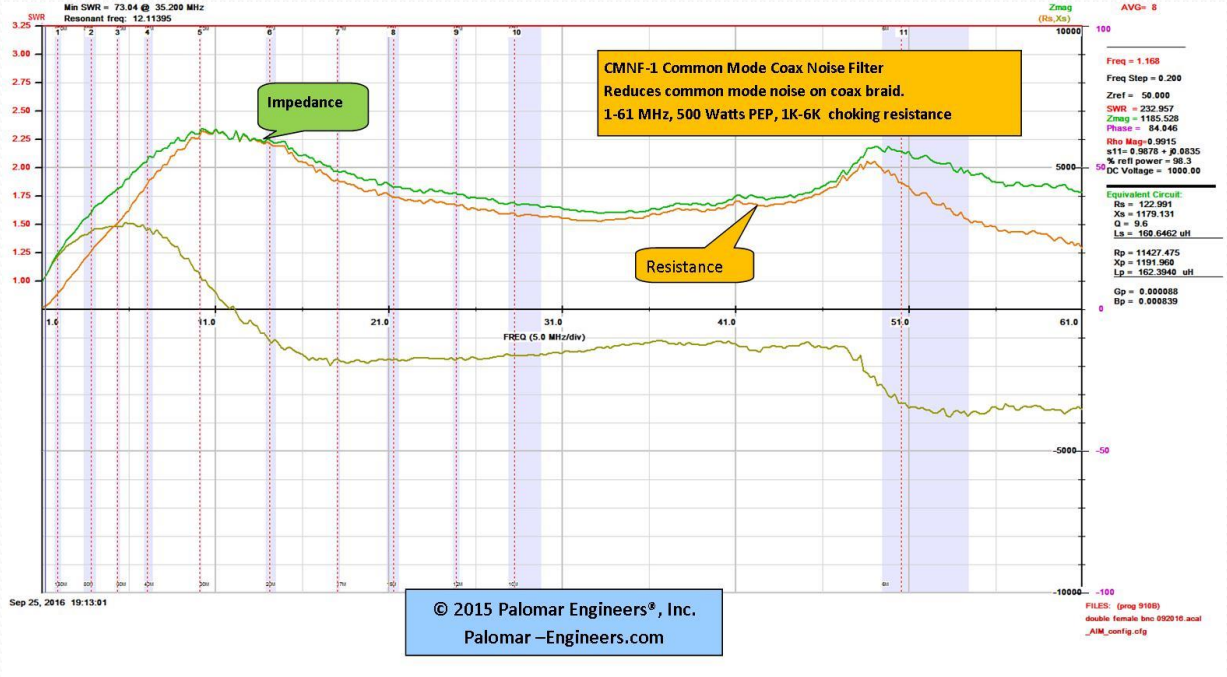
- Symptoms: High noise levels, spurs, buzzes, periodic signals across bands

Typical Receive Chain Connections



Coax Feed Line Noise Filters

>>> One of the best kept secrets in ham radio!!! <<<



Placed at RADIO END of coax feed line to suppress common mode current on coax braid between antenna feed point choke and radio

Now AC/DC Filters

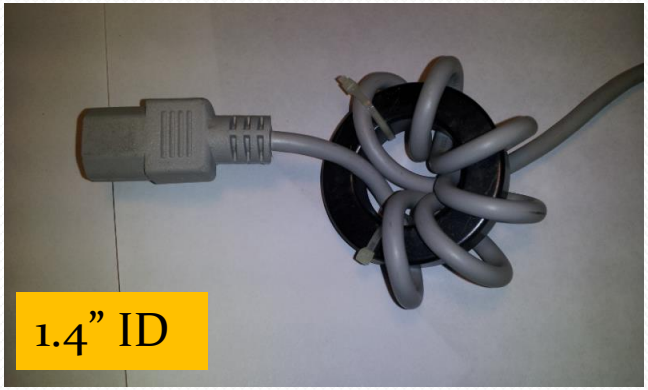
Tip #4. Install AC/DC Noise Filters

Lower Noise Floor = Higher SNR = More DX!

How to select and install filters for maximum effect

Goal is to reduce common mode RFI current superimposed on regular signal INTO “receiver”

RFI – AC/DC Line Chokes



Choose mix frequency range and size to fit cable – use multiple turns

Wall Warts

Wall Wart RFI Noise Reduction Kit

Wall Wart switching DC power supplies that plug into the AC power line plug and provide DC power to laptops, routers, battery chargers, cell phone chargers, etc are a known source of broadband RFI

A simple ferrite ring filter on the DC power line can help suppress the RFI noise affecting the device or keep the DC power cord from acting as an antenna and radiating RFI from the powered device.

RFI Filter on DC Cord

Economy 10 ring kit

Transmit RFI Solution

Receive RFI Solution

Tip #5. Install Solution Specific RFI Kits

Our Goal: Minimize Transmit RFI to Home Electronics and Home Electronics RFI to receiver

Garage Door Opener RFI Kit
Washer/Dryer/Refrigerator RFI Kits
Home Alarm RFI Kit
Computer Desktop, laptop, router RFI Kits
Home Theater A/V Systems

Audio/Video RFI Solutions

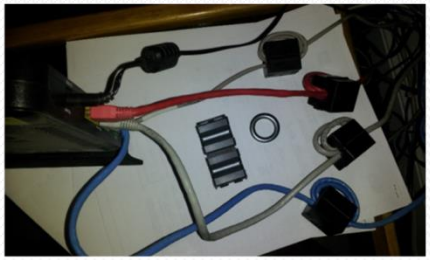
Add chokes to AC power lines first, then interconnect wires – most RFI is from transmitters on low bands (160-30 meters) entering via the power lines, not via the speaker wires!

Neighborhood RFI Solutions

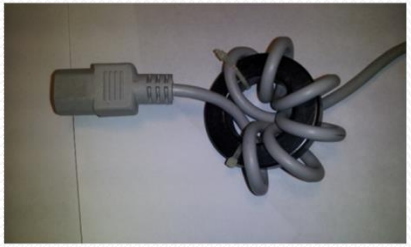
MY HOME or NEIGHBOR'S HOME

ALARM SYSTEM RFI

HOME THEATER RFI



COMPUTER RFI



MISCELLANEOUS RFI

GARAGE DOOR

TELEPHONE/DSL RFI

Recommendation: Use RFI kits for specific problems, have neighbor purchase and install – do not make mods to neighbors equipment! MOST problems are RFI picked up by AC power/phone lines so ferrite filters work well.

Newbies

Receive RFI Solution

Transmit RFI Solution

Tip #6. Use Ferrite Combo RFI Kits for Newbies

Ferrite Combo Kits for Troubleshooting Multiple RFI Issues include multiple ferrite shapes and sizes covering multiple frequency ranges

½" snap ons and 1.4" ID rings are the most popular sizes and can be used to solve most ham radio HF RFI problems

Combo pack of rings and split beads

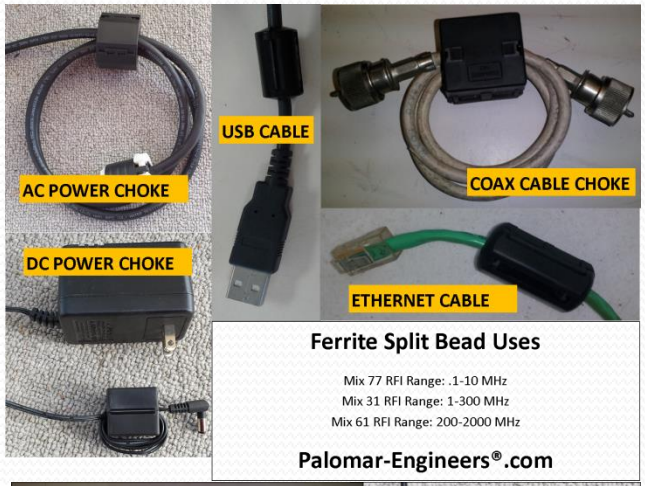
Multi Ring + Snap On

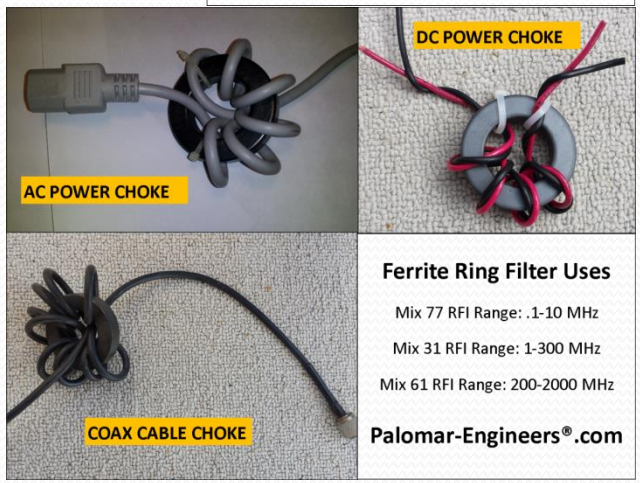
Combo Pack—Mix 31

Ring: F240-31(6) 1.4” ID

Snap On: 3/8”(6), 1/2”(5)

RFI Range 1-300 MHz





- **Use Multiple turns for best results**

Test Time – Win A Prize

Prize Question #1

- What are 2 ways to increase the choking resistance of a ferrite filter choke?

A) Use high resistance wire and multiple turns on bead
B) Use multiple turns and double shield coax
C) Use multiple beads in series with multiple turns
D) Use mix 31 and mix 77 beads in series with a single turn

Prize Question #2

Mix 77 is used in which frequency range to suppress RFI common mode current?

- A) 1-300 MHz
- B) 200-2000 MHz
- C) .1-10 MHz
- D) 1-2000 MHz
- E) CB Band Only

Prize Question #3

- What is one of the best kept secrets in ham radio?

a)Ladder line has more loss than coax

b) A coax wound choke can cover all frequencies from 160-6 meters if the coax is long enough

c) All ferrites work on all frequencies, so buy the cheapest

d) Coax noise filters reduce common mode noise level in your receiver so you can hear more stations

e) All extra class hams go to heaven

Bonus Prize Question #4

- Which company is your best source for RFI solutions?

PALOMAR ENGINEERS®

RFI Solutions from KHz to GHz

- Website: www.Palomar-Engineers.com
- Email: Sales@Palomar-Engineers.com
- Phone: 760-747-3343
- Bob Brehm, AK6R – Chief Engineer
- This presentation available on the website.